

8. On the Vagus and Sympathetic Nerves of *Hyrax capensis*.

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(Text-figures 6-8.)

The present paper is based on the examination of several specimens of *Hyrax capensis*, both immature and fully adult, which died in the Society's Gardens. Variations were observed in the branches of their vagus and sympathetic nerves; and the conditions present in some of the animals are more complex than those already described in my papers on the Marsupialia (3, 4) and Edentata (5). They are also more complex than those in many animals belonging to other orders.

The anterior cervical parts of the nerves are placed deeply, and it is necessary to remove the wide ascending rami of the mandible to gain access to them and their branches.

In all examples the cervical parts of the vagus and sympathetic nerves are fused on both sides to form vago-sympathetic cords, the union taking place at the level of the middle of the thyroid cartilage. The cords are resolved again into their component elements at the root of the neck, but the separation is usually higher on the left side. After they have parted, however, branches of communication may run between them.

THE VAGUS NERVES.

Course:—As it emerges from the foramen lacerum posticum each vagus has the usual relations to the glosso-pharyngeal, spinal accessory and hypoglossal nerves, and it communicates with them and the superior cervical ganglion by well-marked branches (text-fig. 6. CIX, CXI, CXII and S.C.G.). No ganglion nodosum is present in the neck, as in *Tamandua tetradactyla* (4), or within the foramen lacerum posticum. It then courses postero-mesially, gives off communicating branches to the cervical plexus (C.C.P.) and unites with the cervical sympathetic to form the vago-sympathetic cord (V-S) at the level of the middle of the thyroid cartilage. And the nerve up to this point is internal to the mandible. The vago-sympathetic cords break up again in the posterior third of the neck; the vagus half runs still postero-mesially and enters the thorax. Owing to the high level reached by the heart and aorta the first part of the intra-thoracic course is short, but the calibre of the left nerve remains thicker than that of the right one.

Behind the roots of the lungs the vagi are united by a sinuous cord which is as thick as the left vagus (text-fig. 7, *br*), and the nerves emerge again from its extremities, so the arrangement is H-shaped. The left vagus is replaced by right and left branches.

The *superior laryngeal nerve* (*b*) is replaced by a strong cord which unites with one of the divisions of the recurrent nerve. This cord gives off internal laryngeal (*i.l.n.*), two external laryngeal (*e.l.n.*), two thyroid (*t.y.n.*), and three external pharyngeal (*a*) nerves. Small branches (*v.n.*) accompany the common carotid artery. The internal laryngeal branch enters the larynx through the thyro-hyoid interval.

The *left recurrent nerve* (*e*) is given off in the common position. It encircles the aortic arch and runs antero-laterally through the neck. In the middle of the neck it shows a fusiform expansion (*E*) and divides into a mesial nerve (*R.L.N.*), which is the true inferior laryngeal nerve, and a lateral cord (*C*) which unites with the superior laryngeal nerve to form a loop, whose upper part has been described above. Numerous tracheal (*TN*) and œsophageal nerves (*ON*) are given off. They form plexuses of which the tracheal one is the more superficial. And the œsophageal plexus anastomoses with the œsophageal branches of the *right recurrent nerve* (*d*). The latter also forms a loop with the right superior laryngeal nerve, but there is no fusiform expansion. And both recurrent nerves give off cardiac branches (*C.N*) which are thicker and more numerous on the left side.

In some specimens these loops are absent, and there is no external communication between the superior and recurrent laryngeal nerves.

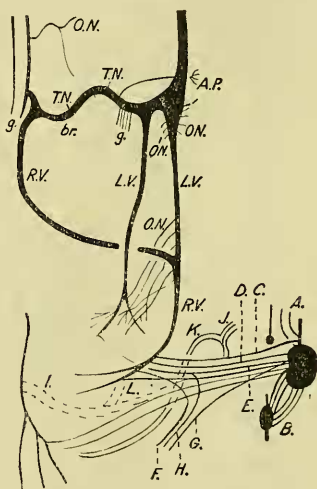
The existence of anastomoses between the laryngeal nerves in Man has long been known. And Landois and Stirling (2) summarised our knowledge as follows:—"A connecting branch runs from the superior laryngeal to the inferior (the anastomosis of Galen), which occasionally gives off *sensory* branches to the upper half of the trachea (sometimes to the larynx?); perhaps also to the œsophagus (*Longet*), and sensory fibres (?) for the muscles of the larynx supplied by the recurrent laryngeal. According to François Frank, sensory fibres pass by this anastomosis from the recurrent into the superior laryngeal. According to Waller and Burckhard, the motor fibres of both laryngeal nerves are all derived from the accessorius, while Chauveau maintains that the crico-thyroid is an exception." In a recent paper Dilworth (1) described and figured a well-marked branch running between the recurrent and internal laryngeal nerves, and says: "... the laryngeal nerves are really a plexus of nerves. Just as the vagus breaks up into its various plexuses in the body, it does the same in the larynx. It is a highly modified plexus. I would further suggest that it arose by the larynx separating a strand of fibres from the vagus—that this strand is represented by the continuous nerve joining the internal and recurrent laryngeal, and that the separation from this strand of further fibres forms the various nerves of the larynx." The conditions shown in text-fig. 6 support Dilworth's views, and I would extend his views of the origin of the laryngeal nerves from the continuous strand to account for the origin of the tracheal, œsophageal, and thyroid nerves.

The *Cardiac Nerves* (text-fig. 6, *f*) arise on the left side from the vagus distal to the origin of the left recurrent nerve, but the right ones arise from the vagus and its recurrent branch. They run to the cardiac plexus wherein they become associated with the sympathetic (C.B.S.).

The *oesophageal nerves* (text-figs. 6, ON, 7, ON, and 8, VB) arise in the neck from the cords uniting the laryngeal nerves. In the upper part of the thorax they are branches of the right vagus, but they come from the two divisions of the left vagus distal to the roots of the lungs.

The *tracheal nerves* (text-figs. 6, T.N and 7, T.N) arise from the laryngeal cords in the neck, but its terminal part and the main bronchi receive their nerve-supply from the thick bridge between the vagi (*br*).

Text-figure 7.



The Lower Thoracic and Abdominal Parts of the Vagus Nerves of *Hyrax capensis*. L.V.: parts of left vagus; R.V.: right vagus. Other letters in text.

The *pulmonary plexuses* (text-fig. 7, *g*):—The right one is formed by two branches from the right vagus and communicating twigs from the deep cardiac plexus. But the left one consists of many branches from the bridge between the two vagi. The latter sends a branch to the *aortic plexus* (A.P.), which receives many twigs from the left vagus. And no ganglia were found in the pulmonary and aortic plexuses.

The *Gastric Nerves* (text-fig. 7):—The left vagus reaches the stomach along the ventral border of the oesophagus and breaks up into two branches. The first gives off twigs which run along

the lesser curvature, and the latter supplies the fundus. Both groups anastomose with branches from the right vagus, and with the celiac plexus. The cord formed by the right vagus and part of the left one supplies the dorsal aspect of the stomach almost to the pylorus. Its branches anastomose with those of the left vagus, and twigs from the celiac plexus. A well-marked branch (splanchnic?) runs to the left sympathetic cord (A). Many of the oesophageal nerves run posteriorly and anastomose with both vagi, so there is a close network round the lower end of the oesophagus and over the left part of the stomach.

THE SYMPATHETIC NERVES.

The *Superior Cervical Ganglion* (text-fig. 6, s.c.g) is round or oval, and flat. It gives off an internal carotid nerve of considerable length (I.C.N) which accompanies the internal carotid artery into the skull. The nerve communicates with the glossopharyngeal and hypoglossal nerves, and the ganglion is connected to the vagus, cervical plexus, and loop between the superior and recurrent laryngeal nerves. But no connection exists between either and the spinal accessory nerve. From the posterior pole of the ganglion the sympathetic cord runs laterally and joins the vagus at the level of the middle of the thyroid cartilage to form the vago-sympathetic cord.

In *Hyrax*, as in all animals possessing the vago-sympathetic cord, no middle cervical ganglion is present, and no direct rami communicantes run to the middle cervical nerves.

The sympathetic separates again in the posterior part of the neck, but communicates with the vagus after the partition. It exhibits a well-marked *inferior cervical ganglion* (I.C.G) on the left side, but none on the right. From the ganglion branches of communication run to the brachial plexus, but I was unable to detect any communication between the right sympathetic and brachial nerves, or between either cord and phrenic nerves. The right sympathetic gives off a branch which accompanies the vertebral artery (V.A.N), and a loop connects it to the right recurrent nerve. And as no branch runs directly to the cardiac plexus, the right recurrent and right vagus nerves conduct all the right sympathetic filaments to the heart.

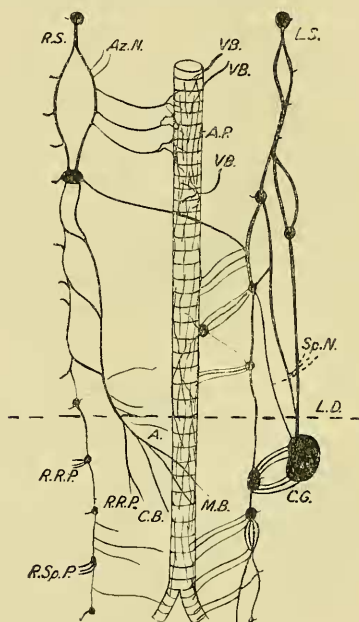
The left inferior cervical ganglion gives off a medium-sized cardiac branch (c.b.s) which runs almost parallel to the left recurrent nerve, passes to the dorsal aspect of the aortic arch and ends in the deep cardiac plexus.

The *Annulus of Vieussens* (A.V) is present only on the left side, and the right sympathetic cord passes in front of the right subclavian artery.

The *left sympathetic thoracic cord* (text-fig. 8, L.s) has few ganglia in its anterior part, and it forms loops. At the level of the middle of the root of the left lung it divides into lateral and mesial divisions. The former possesses a loop and a small ganglion,

and is continued as a thick nerve which ends in the celiac ganglion (text-fig. 8, c.g). The latter ends in a large ganglion whence two nerves emerge. One joins the lateral division and the other becomes the gangliated cord of the sympathetic. In the thorax it gives branches to the aortic plexus (A.P) and a long branch runs to the celiac ganglion. The lateral division of the cord, and the celiac branch of its mesial half constitute splanchnic nerves (Sp.N).

Text-figure 8.



The Thoracic and Abdominal Sympathetic of *Hyrax capensis*. V.B: aortic and oesophageal branches of the vagi; L.D: line of diaphragm. Other letters in text.

The abdominal part of the left sympathetic (text-figs. 7 and 8) possesses four ganglia. It gives off two groups of lateral branches to the semilunar ganglion, rami communicantes to the lumbar nerves, and branches to the aortic plexus. It has a great tendency to subdivision.

The thoracic part of the right sympathetic (text-fig. 8, r.s) has few ganglia in the anterior part, and its posterior part is very complicated, but not so much as the left cord. It divides into mesial and lateral parts and these are united at intervals by common ganglia or communicating branches. The lateral division ultimately continues the cord back to the sacrum. The mesial division is thick and strong. Branches of the cord run to

the aortic plexus (A.P), vena azygos major (Az.N), thoracic nerves, and left sympathetic.

In the abdomen the mesial division divides into two, and the following are the fibres of distribution :—

1. To the celiac ganglion (A).
2. Hepatic plexus (contained in A).
3. Phrenic plexus (contained in A).
4. Fibres to the right renal plexus (R.R.P).
5. Fibres to Meckel's Tract and Duodenum (M.B).
6. Fibres to the colon (C.B).

The abdominal part lies close to the left sympathetic and fibres connect them. It gives off the right renal plexus (R.R.P), right spermatic plexus (R.S.P), and filaments to the aortic plexus.

The *Cardiac Plexus* consists almost entirely of the deep part, the superficial plexus consisting only of a few filaments derived from it. The nerves entering into it are :—

1. Three branches of the left vagus.
2. A twig from the left recurrent nerve.
3. A branch from the inferior cervical ganglion of the left sympathetic.
4. Two branches from the right recurrent nerve.
5. Two branches from the right vagus.

No ganglia are present, nor are there separate depressor nerves ; but these may be contained in the loops uniting the superior and recurrent laryngeal nerves. Offshoots of the plexus can be traced into the pulmonary and tracheal plexuses.

The *Aortic Plexus* (A.P) derives its fibres from the two sympathetic cords, the bridge between the vagi in the thorax, and the solar plexus.

The *Solar Plexus* (text-fig. 7):—In the upper part of the abdomen dorsad of the stomach there is a broad band of fibres with a large reddish-brown semilunar ganglion at its left extremity. The fibres are closely packed and have wide connections as follows :—

1. The splanchnic nerves from the left sympathetic cord entering the anterior pole of the ganglion (A).
2. Two bundles of fibres from the left sympathetic cord entering the mesial border of the ganglion (B).
3. Fibres from the right vagus to the large left splanchnic nerve (C).
4. Fibres from the right vagus to the semilunar ganglion (D).
5. Fibres from the left vagus to the semilunar ganglion (E).
6. Fibres from the right vagus running into the plexus and turning down to the splenic plexus (F).
7. Fibres from the semilunar ganglion to the splenic plexus (G).
8. Branches from the solar to the splenic plexus (H).
9. Branches from the right sympathetic to the semilunar ganglion (I).
10. Hepatic plexus (J) giving off pyloro-duodenal nerves (K).
11. Diaphragmatic plexus (L).

SUMMARY AND CONCLUSIONS.

1. In all examples of *Hyrax capensis* the cervical parts of the vagus and sympathetic nerves are fused. And the ganglion nodosum is frequently absent in the neck.

2. The recurrent and superior laryngeal nerves are frequently, but not always, connected by a loop.

3. There is no separate depressor nerve.

4. The internal carotid nerve has a very long cervical course.

5. The right recurrent nerve has well-marked cardiac branches.

6. The left sympathetic alone has an inferior cervical ganglion and an Annulus of Vieussens.

7. The posterior thoracic parts of the vagi have a complicated arrangement.

8. The thoracic sympathetic cords have few ganglia, and there is only one semilunar ganglion.

9. The right sympathetic is distributed to the colon, and the left one and celiac plexus supply the small intestines.

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5. „ „ *Proc. Zool. Soc. London*, 1922, pp. 99–180.